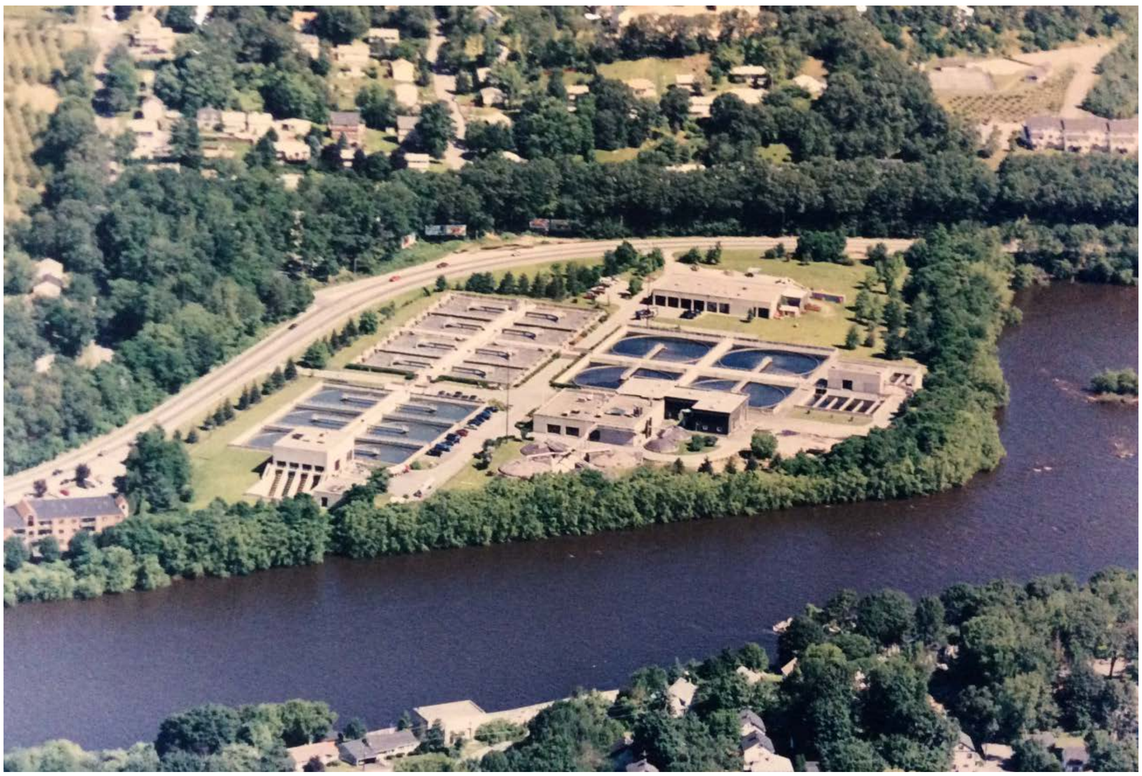
Draft Bacteria Monitoring Plan for the Merrimack River Watershed

Lowell Water Engineering Division & Merrimack River Watershed Council



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1. Background

Bacterial contamination of the Merrimack River is of concern to recreational users of the regional waterbody, as well as to water-quality managers and advocates. Combined Sewer Overflows, urban stormwater runoff, illicit discharges of sewage and septic systems, and natural sources of bacteria such as wildlife combine in this lowland watershed to create numerous sources of pathogen risks that at times exceed safe recreational criteria. The public is presently without a single authoritative source of information regarding the potential risks associated with enjoying the Merrimack River following wet-weather events.

Bacteria monitoring is conducted by multiple entities, published in disparate fashion, and is often not available in adequate time to support recreational decisions around holidays important to the local tourism industry.

Fortunately, recent technological advances have been made allowing for development of an integrated instrument designed for nearly real-time automatic sampling, analysis and reporting of microbial water-quality. Although not yet approved by the US EPA, the technology is peer-reviewed and is in use in many applications in Europe and in the Western US.

Fluidion, *Inc.*, developed, tested and manufactures the Automatic Lab-in-vial *E.coli* Remote Tracking (ALERT) system (D.E. Angelescu, August 2018). The ALERT system allows for rapid quantification of *E. coli* or, through alternative configuration, enterococci bacteria commonly used as an indicator of risk for exposure to human fecal bacteria in fresh and marine waters, respectively. The system is installed on a dock or affixed to a floating raft or buoy and collects water samples from the water body of interest upon receipt of a cellular signal. The system houses seven individual bioreactors, each of which collect a water sample on schedule, incubate and measure bacterial growth response indicators (time to fluorescence), and use proprietary algorithms through cellular networks and cloud computing to rapidly (within 2-12 hours) report a 'most-probable-number' (MPN) of bacteria per 100 milliliters of water. The time to result (TTR) is dependent on bacterial concentration and decreases with increasing concentration – thus, rapid notification of high levels of bacteria may be disseminated to the public-at-large and may be used to inform decisions regarding recreational use.

Several of these instruments placed along the river in consideration of various bacteria loading sources (major tributaries, CSO discharge locations, urban stormwater inputs, et cetera) may be coordinated into a single monitoring network to increase the prediction of unsafe conditions throughout the river, and to determine when it is safe to resume recreational use of the river.

However, such a program needs more than just instrumentation. A responsible and technically skilled monitoring-program manager is needed to ensure proper deployment protocols are followed, maintain the equipment, and disseminate information obtained through the network. An interstate watershed requires an interstate manager, such as the New England Interstate Water Pollution Control Commission (NEIWPCC), which conducts watershed monitoring programs in the Hudson River, Long Island Sound, Lake Champlain, and elsewhere in New England. NEIWPCC is a representative commission appointed by the governors of its seven member-states in New England (and New York). All member states, as well as the Federal government, contribute to funding NEIWPCC.

Absent involvement from NEIWPCC or a similarly focused interstate commission, it may be difficult to coordinate the requisite information and resources necessary to implement an advanced alert system throughout the watershed such as is proposed here.

2. Monitoring Locations and Related Considerations

The Merrimack River is actively used for recreation throughout its length in Massachusetts and New Hampshire. Monitoring locations are proposed downstream of any major urban area contributing significant stormwater runoff or combined sewer overflow (CSO) discharges to the river or its major tributaries, in order to facilitate reliable information users of the river in these areas. In addition, two beaches in Newburyport, MA are areas of highly concentrated recreational activity in the summer and are selected for additional monitoring due to the high volume of visitors.

Specific sites downstream from selected areas are initially proposed near bridges where instruments may be securely fixed to downstream bridge abutments where they will be protected during high flow events and relatively accessible for maintenance. Maintenance access will be a primary concern for site selection in later drafts of the monitoring framework, once general locations have been narrowed down and agreed upon.

Aside from maintenance access, an equally important consideration in locating monitoring instruments is whether the location is representative of the bulk water-quality moving downstream. Placing monitoring equipment directly on shorelines or in stagnant coves or inlets may result in high bacteria counts compared to a “composite” sample (combined from several sampling points across the river section) at the same location. This would then suggest that more bacteria are being carried downstream than is actually occurring. Monitoring equipment should be installed in a section of the river that is adequately deep and far from shore so as to accurately represent the bulk water-quality of the river segment.

A potential alternative to placing monitoring equipment in the flow of the river may be to install them at secure stations (lockers) on the shoreline, and then pump water from the river to the sampler continuously or on demand once the sampler is triggered. However, this would increase the complexity and cost of installation and instrument programming, perhaps prohibitively for locations where electrical power may be difficult to access.

The following general site list is presented from upstream to down, and includes 12 instrument locations (a map of these locations is provided at the end of this proposal):

Table 2-1. Proposed Monitoring Locations	
Main-stem Locations	
Downstream of Concord, NH	Route 3 (Manchester Street) Bridge
Downstream of Manchester, NH	Raymond Wieczorek Drive
Downstream of Nashua, NH	Circumferential Highway
Downstream of Lowell, MA	Interstate 93
Downstream of Lawrence, MA	Second 495 Crossing
Downstream of Haverhill, MA	Bates Bridge
Downstream of Amesbury, MA	Main Street Bridge
Newburyport, MA	Salisbury Beach
Newburyport, MA	Plum Island at entrance to The Basin
Tributary Locations	
Nashua River downstream of Leominster, MA	Mechanic Street Bridge (upstream of Leominster State Forest)
Nashua River downstream of Paper Mill Village	South Street Bridge (upstream of J. Harry Rich State Forest)
Concord River downstream of Billerica, MA	Boston Road (129) Bridge

3. Equipment and Maintenance Estimate

A 15% contingency is added to the development costs as well as to the annual O&M budget. Initial up-front costs to get the proposed monitoring network developed, installed, and communicating actionable results to the public would cost on the order of $690,000 the first year, with a recurring annual cost of roughly $220,000 for operations and maintenance. Details are provided below and in the table at the end of this section.

Up-front Development Tasks and Item Costs

The following estimate includes up-front costs for the *Fluidion* monitoring equipment at the 12 proposed locations, site-selection and installation costs (finalizing selection of general locations and specific installation plans for each site).

Additionally, the communications protocol for each instrument needs to be developed – specifically what events will trigger a sampling sequence and how long will that sequence last. This may depend on results from upstream sampling points in a modulated chain-reaction, coordination with local wastewater utilities discharge reports, or it may be as simple as automating triggers based on local rainfall.

Finally, a reporting framework, for example in ArcGIS Online (AGOL) maps similar to EPA's *Merrimack River StoryMap*, will need to be developed. This will take some computer programming effort to develop in a manner that will be easily maintained and automatically updating with new results and precipitation events. Public access to AGOL maps can be enabled by the monitoring program manager, and an AGOL organizational account is required, which incurs an annual licensing fee (shown in the Annual Operations & Maintenance (O&M) section of the budget).

Operations and Maintenance Costs

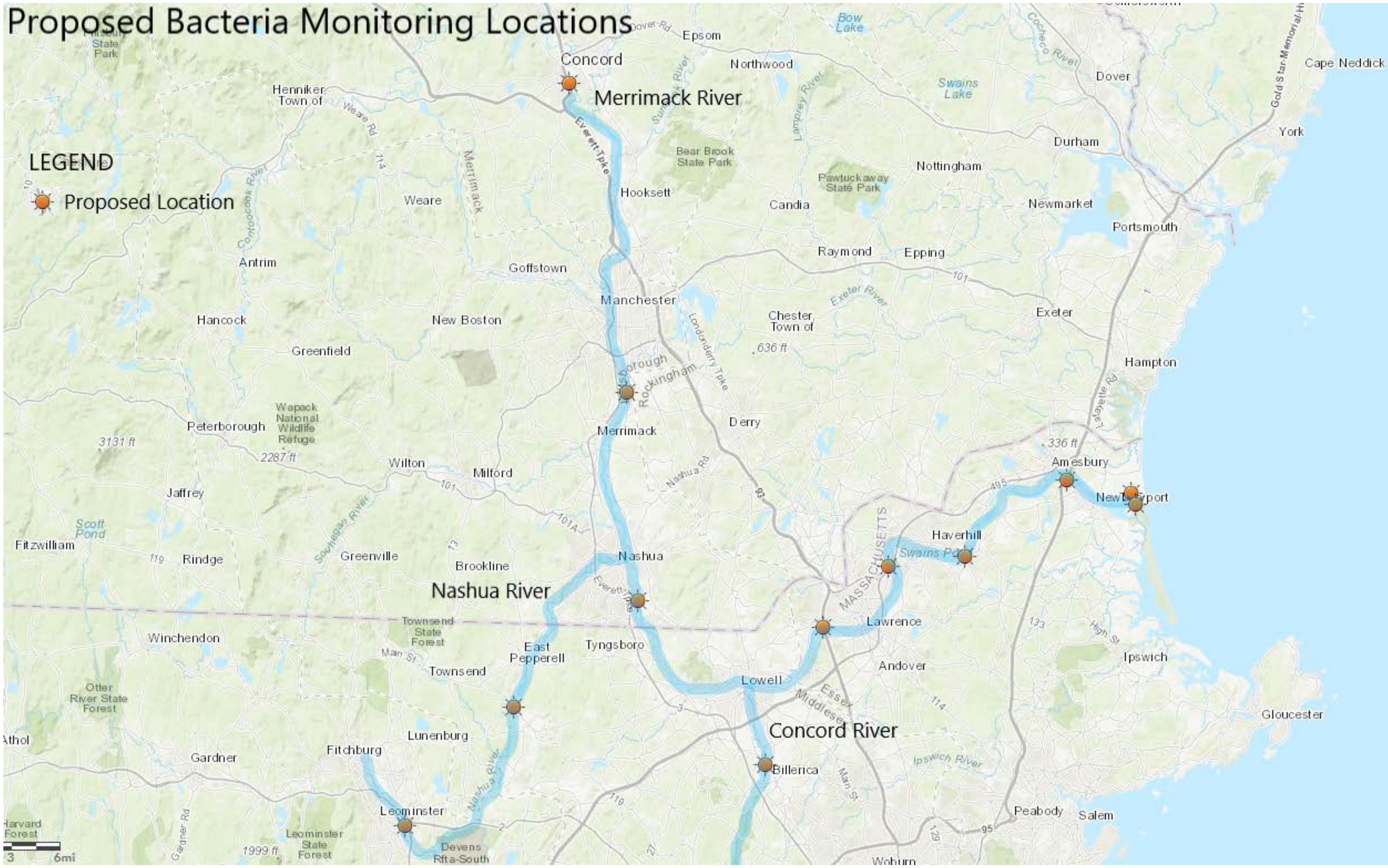
As previously discussed, annual operations and maintenance costs will be incurred by the managing agency or commission responsible for the monitoring network. The estimate does not include costs such as boats to access instrumentation, vehicles to transport equipment, hand and power tools for installation, et cetera. It is assumed that a properly delegated network manager or contractor would already have such equipment on hand.

The annual O&M cost is comprised of:

- Chemical reagent consumed in the analytical process. Each instrument can collect seven samples per deployment, and the estimate assumes that a full set of seven will be analyzed for each CSO-related event sampled. At an assumed 50 CSO-related wet-weather events each year and 12 monitoring locations, a total of 600 reagent sets are needed each year.
- Each instrument needs to be cleaned and reloaded after each such event, which is listed as 'continual maintenance' in the budget estimate.
- Each instrument needs annual factory recalibration

Table 3-1. Proposed Watershed Monitoring Budget			
Development Items/Tasks	**Unit Cost**	**Units**	**Total Capital**
ALERT System	$ 28,000.00	12	$ 336,000.00
Site Selection and Installation	$ 2,000.00	12	$ 24,000.00
Communications Protocol & Reporting Tools (e.g., interactive online maps and charts)	$ 50,000.00	1	$ 50,000.00
Development Estimate with 15% Contingency			*$ 471,500.00*
Annual O&M			
Reagent sets (7 tests per set, 1 set per sampling event)	$ 70.00	600	$ 42,000.00
Annual factory maintenance	$ 2,160.00	12	$ 25,920.00
Continual maintenance ($200 per event per instrument)	$ 200.00	600	$ 120,000.00
ArcGIS Online Licensing	$ 1,000.00	2	$ 2,000.00
Annual O&M with 15% Contingency			*$ 218,408.00*
First-year total (Development + O&M)			**$ 689,908.00**

4. Monitoring Locations Map



5. References

D.E. Angelescu, e. a. (August 2018). Autonomous system for rapid field quantification of Escherichia coli in surface waters. *Journal of Applied Microbiology*, 332-343.